Permeation behavior of olefin/nitrogen/hydrogen through PDMS dense and composite membranes

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Abstract

The worldwide annual production of polyolefins amounted to 60 million tons in 2000. During the process, 1-2 wt% of the olefin monomers have been emitted and flared into the air, causing the huge energy consumption and severe carbon dioxide emission. Recently, membrane process has been proved to be the most competitive among other separation processes in terms of cost of equipments, energy consumption and safety in this application. The performance of membrane process highly depends on the membrane properties and thus, it is very important to develop good membrane materials and composite membranes.

We prepared PMDS dense and composite membranes and studied basic permeation behaviors of a series of olefins(ethylene, propylene, 1-butylene), nitrogen and hydrogen as model gases.

Experimental

- **Preparation through dense PDMS polymer film**

PDMS polymer film was prepared by the solvent-casting method. Base and curing agent were dissolved into n-hexane and then carefully cast onto teflon plates and, the plates were placed in oven at room temperature for 24 hours. The polymer films were then heated up to 110℃ for 2 hours.

- **Gas permeation**

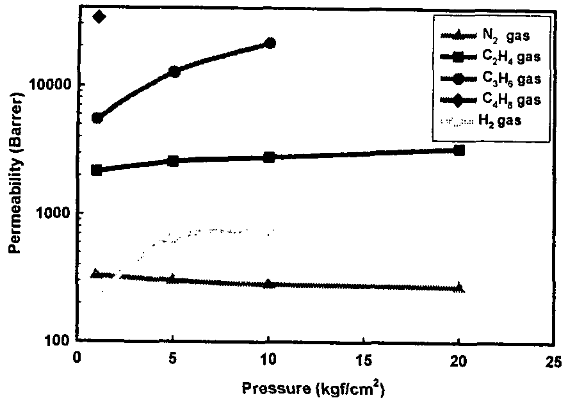
Pure gas permeabilities were checked by bubble flow meter. Testing temperature and pressure were controlled from -30 to 50℃and from 1 to 25 atm, respectively. The dense PDMS membranes prepared have good mechanical strength for high-pressure membrane test. The ideal separation factor(ideal selectivity)is defined as the ratio of pure component permeability.

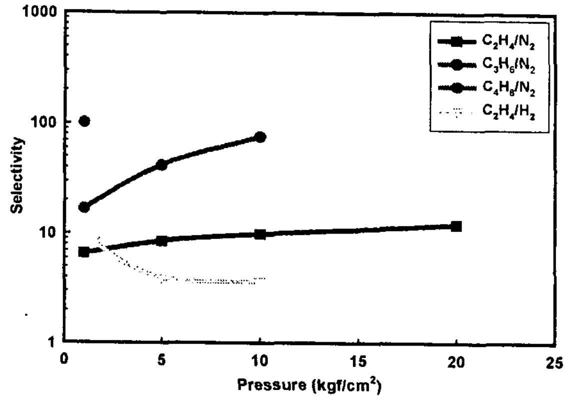
- **Preparation of composite membrane**

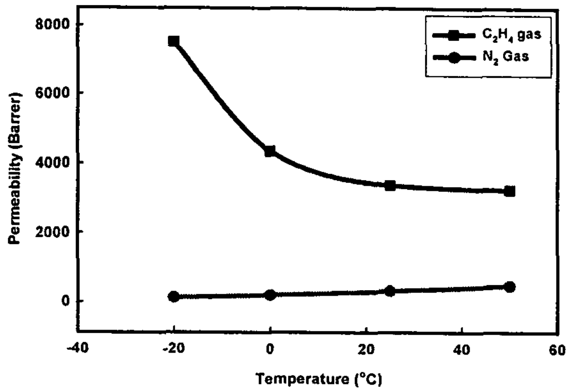
Plyetherimide(PEI) or polyethersulfone(PES) asymmetric support membranes were made by dry/wet phase inversion method. The coating thickness was controlled by varying the polymer concentration in the coating solution. The structure and geometrical characteristics of the produced composite membranes were studied by scanning electron microscopy(SEM) using a JSM-840A.

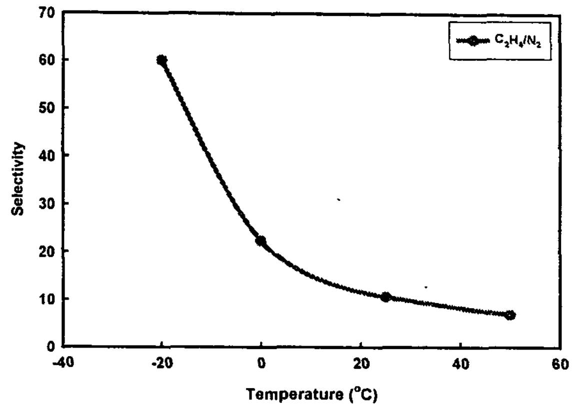
Results and discussion

- **The effect of feed pressure and temperature on permeability and selectivity for dense membrane**









The permeabilities of olefins and hydrogen increases with increasing feed pressure, while that of nitrogen decreases slightly. The selectivities of olefin/nitrogen and hydrogen/nitrogen increase with operation pressure, but that of olefin/hydrogen decreases. The permeabilities of olefins and their selectivities over nitrogen are in the following order: 1-butylene> propylene > ethylene, which is the same order of condensation temperature of olefins, not the order of olefin size. As test temperature decreases, the permeabilities of ethylene increase highly but nitrogen decrease slightly and thus, ethylene/nitrogen selectivity increase highly. The permeation behaviors matched well with the general permeation behavior of rubbery polymeric membranes for condensable and non-condensable gases<solution-diffusion theory>. The composite membranes with optimum coating conditions showed similar permeation behavior as dense membranes.

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